REMARKS

In light of the amendments presented above and the following remarks, reconsideration and allowance of the present application are hereby requested. A Request for Continued Examination and the requisite fee have been submitted along with this Amendment and Response.

Claims 34-48 were pending for the Office Action dated November 27, 2002. Claims 36 and 37 stand rejected under 35 U.S.C. §112 as being indefinite for failing to point out and distinctly claim the invention. Claims 34-39 and 42-45 stand rejected under 35 U.S.C. §102(b) as being anticipated by Nath. Claim 40 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Nath in view of U.S. Patent No. 5,539,546 to Koden. Claim 46 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Nath in view of Kwok. Claims 46 and 47 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Nath in view of U.S. Patent No. 6,437,363 to Kadota. Claim 48 was withdrawn by the Examiner as being directed to a non-elected invention.

Applicant has canceled claims 45 and 48; amended claims 34, 36, 37, 44, 46 and 47; and added no new claims. Claims 34-44, 46 and 47 are currently pending in the application. For the reasons set forth below, reconsideration of the amended application is respectfully requested.

It is respectfully submitted that independent claims 34 and 37, as amended by the present Amendment and Response, and their respective dependent claims are allowable over the references of record. All of the prior art rejections rely on Nath, either exclusively or in combination with other references. Nath (Thin Solid Films, 72 (1980) 463) teaches an experimental description of producing a thin film in quartz crystalline substrates. However, Nath does not show that the substrate used therein is a single crystalline substrate or polycrystal substrate. In addition, if the substrate used in the experiment were a crystal substrate, whether single crystal substrate or polycrystal substrate, the electron beam diffraction pattern would be spot-shaped due to the substrate characteristics, regardless of the film production temperature. However, since FIG. 4a in Nath does not show such a pattern, it is considered that the thin film sample is produced on a glass substrate. Further, Nath does not contain any disclosure that the thin film produced on a quartz crystal substrate is an epitaxial film, which means that the crystallographic axis of the substrate and that of the thin film is arranged in parallel.

On the other hand, according to the present invention, the substrate is a single crystal substrate and the film produced thereon is an epitaxial film, in which the crystallographic axis of the substrate and that of the thin film is arranged in parallel.

Further, Nath reported the production of thin film having a resistivity of $7x10^{-5}$. However, Nath does not teach how this resistivity is realized. In particular, Nath fails to provide a reasonable description about the relationship between resistivity, carrier density and mobility. Nath discloses that mobility is in the range of 20-30 cm^2/Vs and the carrier density is approximately $1x10^{21}/cm^3$ (p466). When the resistivity is calculated based on the maximum mobility of 30 cm^2/Vs and carrier density of $1x10^{21}/cm^3$, the resistivity is obtained as $5x10^{-4}$, which is not close to $7x10^{-5}$.

With respect to claim 46, Kwok (Thin Solid Films, 82 (1980) 463) teaches that ITO thin film is manufactured on a YSZ single crystal substrate and only a (400) diffraction beam can be observed by an X-ray diffraction. This means that the x-axis of the ITO lattice is parallel to that of the YSZ lattice or the YSZ is ITO oriented. However, Kwok does not refer to the y-axis and the z-axis and thus, there is no guarantee that the sample in Kwok is an epitaxial film.

According to the present invention, the thin film produced on the substrate is an epitaxial film. This means that the x-axis, y-axis and z-axis of the thin film crystal lattice is parallel to those of substrate crystal lattice, respectively.

When the y-axis and z-axis of both of the lattice is not parallel or the thin film crystal lattice is rotated around the x-axis on the substrate, the mobility reduces so as to increase the electric resistivity due to unmatching of

the lattice in the boundary of thin film crystal lattices. When a light emitting device such as an LED is produced on an ITO film, it is preferable that each layer has an epitaxial relations. However, when ITO is not an epitaxial film, it is impossible to produce an LED having such a relationship.

Kwok shows that the half width in X-ray diffraction is 0.08° and electric resistivity is $3x10^{-4}$ Ωcm. However, Kwok does not show the relationship between the crystal structure and the electric resistivity.

According to the present invention, low resistivity is achieved by increasing crystal structure of the thin film. In general, the carrier density has a trade-off relationship with mobility. This means that when the carrier density is increased, mobility is decreased, which defines a minimum level of electric resistivity. However, according to the present invention, the activating ratio of Sn dopant is improved to more than 80% so that carrier density is increased. In addition, the reduction of mobility is restrained to maintain a value greater than 39 cm^2/Vs. As a result, a low resistivity less than $1x10^{-4}$ Ωcm can be realized with high repeatability.

In order to realize this, it is not sufficient to increase the crystality of the thin film so as to narrower the half width value in X-ray diffraction and it is required to control Sn dopant content in the film and to dope Sn dopant in $In3^4$ site in In_2O_3. The present invention can achieve a low resistivity of less than $1x10^{-4}$ Ωcm with high repeatability.

CONCLUSION

Attached hereto are two (2) pages which present a marked up version of the changes made to this application by the current amendment. The first page of the attached pages is captioned "**MARKED UP VERSION PURSUANT TO 37 CFR 1.121**."

Applicant has amended six (6) claims, cancelled two (2) claims, and added no new claims. Applicant respectfully requests a Notice of Allowance for pending claims 34-44, 46 and 47. The undersigned welcomes a telephonic interview with the Examiner if the Examiner believes that such an interview would facilitate review of this Amendment and Response.

Respectfully submitted,

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MARKED UP VERSION PURSUANT TO 37 CFR 1.121

IN THE CLAIMS

Claims 45 and 48 have been cancelled without prejudice to their consideration in a continuing application.

Claims 34, 36, 37, 44, 46 and 47 have been amended as follows:

34. (Currently Amended) A low resistance ITO thin film having a resistivity less than 1 X 10 $^{-4}$ Ω cm, said film deposited on a single crystalline substrate by epitaxial growth.

36. (Currently Amended) A low resistance ITO thin film according to claim 34, wherein film mobility is greater than 39 cm^2/Vs.

37. (Currently Amended) A substrate having a low resistant ITO thin film comprising:

a single crystalline substrate; and

a low resistance ITO thin film having a resistivity lower than 1 X 10 $^{-4}$ Ω cm [produced for deposition] deposited on said single crystalline substrate by epitaxial growth.

44. (Currently Amended) A substrate having a low resistant ITO thin film according to claim 37, wherein said single crystal substrate is provided to accept an In_2O_3 crystal structure deposited thereon.

46. (Currently Amended) A substrate having a low resistant ITO thin film according to claim 37, wherein said single crystalline substrate is one of a YSZ single crystal substrate, a substrate on which a C-axis oriented Zn0 thin film is formed, a sapphire substrate, a SiC single crystal substrate and a silicon single crystal substrate.

47. (Currently Amended) A substrate [haaving] having a low resistant ITO thin film according to claim 37, wherein said single crystalline substrate has a C axis oriented Zn0 film formed thereon.